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Water adsorption kinetics and diffusion in dense SAPO-34 layers on porous aluminium fibre structures – macroscopic measurements by a Volumetric Differential Pressure Step Method

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Adsorptive heat transformation is of rising interest for heat storage, heat pumping and thermally driven cooling. By using solar or waste heat as the driving energy, such systems can significantly help to minimize primary energy consumption and greenhouse gas emissions. In adsorptive heat transformation, a coolant liquid, preferably water, is cycled between a liquid phase and an adsorbed phase in a closed system.

To enhance heat and mass transfer while keeping a good mass ratio between active adsorbent and passive thermal mass (heat exchanger), Fraunhofer ISE in cooperation with partners (Fraunhofer IFAM, SorTech AG) is developing novel adsorber heat exchanger (AdHex) geometries based on porous metal supports covered by compact adsorbent layers (see Fig. 1). In a most innovative implementation of such an AdHex, the internal surface of macroporous aluminium fibre structures is covered by a dense poly-crystalline adsorption layer of the active zeolitic adsorbent (see Fig. 1, right) such as e.g. SAPO-34, a zeolite with CHA framework type, in which aluminium is partially exchanged by phosphorous. In first investigations of the coupling between mass transfer and heat generation in such systems it was found that the water diffusion in the SAPO-34 layers can represent the dominating step in effective heat generation of such heat transformation systems.

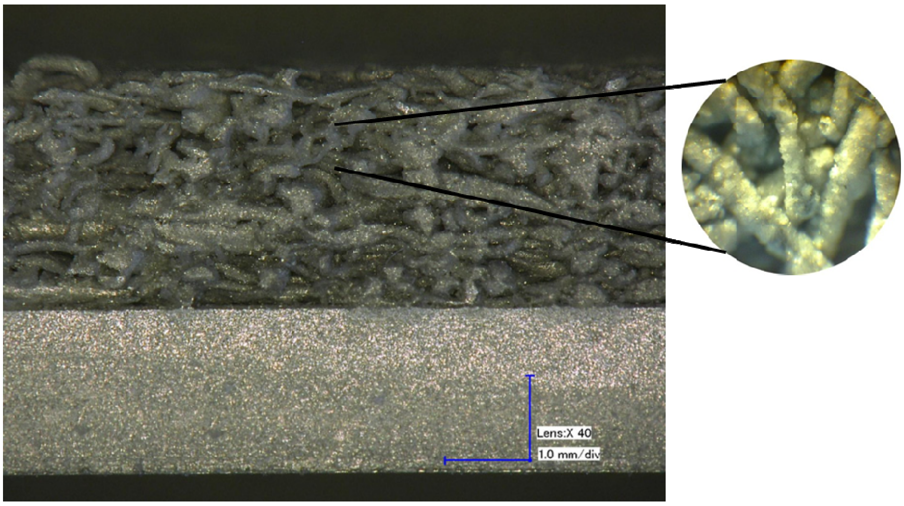

Figure 1: Sintered aluminium fibre structure on aluminium sheet metal, covered with SAPO-34 directly crystallized on its surface.

By a volumetric quasi-isothermal differential pressure step method, the transient uptake process is macroscopically characterized at three different temperatures (30,40,50°C) for two different samples with a variation of average SAPO-34 layer thickness (14 and 24 µm). By interpreting the measured uptake curves as a process that is dominated by adsorbed phase diffusion in the compact adsorbent layer and taking into account the previously measured adsorption isotherms, temperature and loading dependent diffusion coefficients are obtained. Comparison to diffusion coefficients obtained by IR imaging and PFG-NMR measurements on larger layer thicknesses and SAPO34 powder, performed at University of Leipzig in a common research project (WasserMod), give hints that the obtained diffusion coefficients are slightly lower for the thin layers than for thicker layers or powder.